"Leveraging our Federal Research and Development (R&D) Investment Through Technology Transfer"

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Introduction

Mr. Chairman it is a privilege to come before you and the subcommittee members to discuss this extremely important issue of technology transfer and its relationship to federal research and development (R&D) as well as its impact upon society and our nation's economy.

As the Chair of the Federal Laboratory Consortium for Technology Transfer (FLC), I wish to thank you for the invitation to address the committee. I would also like to express gratitude on behalf of the FLC for your untiring efforts to promote legislation which serves to better equip our federal laboratories with the necessary tools to deal with many of the challenges facing the diverse technology transfer community. We continually work with Congress to improve the technology transfer legislation, and additional strides can be made at this time, as certain specific refinements are needed in federal technology transfer procedures. As you know, the Technology Transfer Commercialization Act (H.R. 209) recently passed the Science Committee in the House. A companion bill was introduced in the Senate in the 105th Congress, and we are anxious for that bill to be reconsidered and approved by the Senate during this session of Congress.

In preparing for this hearing, we have solicited and received comments from a number of our member agencies. Please recognize that we have not received the "official" agency positions, but rather their thoughts on this very important issue.

In this full statement, we provide many detailed examples of successful technology transfer that has had significant impact in leveraging federal R&D programs.

Overview of the Federal Laboratory Consortium

The FLC is the nationwide network of federal laboratories that provides the forum to develop strategies and opportunities for linking laboratory technologies and expertise with the marketplace.

The FLC has been in existence in some form since 1974. The passage of the Stevenson-Wydler Technology Innovation Act of 1980 provided increased stimuli for the growth and development of the FLC. The Federal Technology Transfer Act of 1986 provided a Congressional charter and funding mechanism, creating the FLC as we know it today. (Attachment 1 to this testimony provides "Technology Innovation Legislation Highlights," noting these and other laws.) We are appreciative of the fact that the FLC is officially chartered by Congress.

The FLC includes more than 700 laboratories and technical facilities representing the breadth of the agencies of the U.S. government. Technology transfer activities within each federal agency and laboratory have the general objective of enhancing the social and economic posture of U.S. industry in the global marketplace. The FLC's overall mission is to add value to those agencies, laboratories, and their partners by helping to <u>rapidly</u> integrate R&D resources to the U.S. economy.

The FLC's vision for the nation envisions that technological R&D in the United States is the best in the world. Each year, approximately $25 billion of federally funded R&D takes place at the more than 700 federal laboratories I mentioned earlier. This includes more than 100,000 scientists and engineers working at those facilities – addressing virtually every area of science and technology. The scope of technology transfer at those facilities involves: support of agency missions; use of incoming technology (spin-ons); and the transfer of technology to non-federal sectors such as U.S. business and state and local governments. Clearly, the FLC cannot accomplish this vision for the nation by itself. It intentionally focuses on a high level national goal to which the FLC is one of a number of important contributors. The FLC's member laboratories and agencies comprise another group of important contributors.

The FLC's <u>own</u> vision is to strive to be perceived as the recognized leader in supporting federal technology transfer and maximizing collaborative research. The FLC is creating an environment conducive to successful technology transfer on the part of its member agencies by serving as a broad-based forum to share best practices and lessons learned, as well as to reduce barriers and resolve issues that may impede technology transfer.

<u>FLC Strategies</u>

The FLC pursues this vision and accomplishes its mission through many venues such as its officers, committees, and members. Each of these components work to implement certain strategies that make up the FLC strategic plan. The FLC's current "Strategic Plan for the 21st Century" is designed to meet our members' future needs. In implementing the plan, we have identified six strategic focus areas. In short, the FLC is working to: (1) create innovative partnerships, (2) influence technology policy, (3) optimize diverse resources, (4) strengthen its structure, (5) lead its vision, and (6) project a positive and consistent image.

More specifically, in creating innovative partnerships, the FLC is listening to industry and interacting with trade associations, and responding to their technological needs. In influencing technology policy, the FLC is capitalizing on its experience and expertise in technology transfer to influence the science and technology policy debate. In optimizing diverse resources, the FLC is coordinating on an interagency basis to develop improved opportunities for moving government technologies to the market. To strengthen its structure, the FLC is continually reinventing itself to match the new, emerging technology needs of the twenty-first century. In order to "lead its vision," the FLC is anticipating the future demands of changing inquiries and resources to make the most of federal technology. Finally, to project a positive and consistent image, the FLC is taking every opportunity to raise the awareness of successful technology transfer between laboratories and industry, and to explain and publicize the FLC mission and services.

Attached to this testimony is a one-page sheet summarizing the FLC's vision, mission, goals and objectives, and strategies (see Attachment 2).

FLC Services

As noted above, there are a variety of components to the FLC network. These include the Executive Board, regional coordinators, committees, National Advisors Group, Washington DC office, Management Support Office, ad hoc groups, and of course members. All of these components of our network share the legislative requirement to fulfill the FLC's statutory mandates for technology transfer. These mandates include, but are not limited to, the following examples:

- providing training in technology transfer to federal laboratory employees,
- providing a clearinghouse for technical assistance,
- advising and assisting federal agencies and laboratories with their technology transfer programs, and
- facilitating communication and coordination between federal laboratory ORTAs (Offices of Research and Technology Applications, per 1980 legislation) and regional, state, and local technology transfer organizations.

In its twenty-five years of existence, the FLC has developed experience and expertise in providing a cadre of services for its member agencies. Per our legislative mandates, this includes, among others: training, trade association and trade show participation, public relations, and liaison with other technology policy-oriented organizations. Over the years, the FLC has honed and targeted its training programs. These programs now include sessions oriented towards the following topics: new FLC representatives, laboratory technology transfer officers, intellectual property issues, cooperative R&D agreements, advanced technology transfer training, and professional development skills. Furthermore, through its marketing and public relations committee as well as through its Washington DC office, the FLC interfaces with a variety of technologically-oriented trade associations. The FLC participates in twelve trade shows per year in identified technology areas, such as biotechnology, manufacturing, automotive, environmental, electronics, computers, sensors, materials, photonics, assistive technologies, and food processing and agricultural areas. An example of an FLC committee is the FLC State and Local Government Committee. As a service to state and local government officials, this committee provides seminars to raise their awareness about the FLC and technology transfer opportunities with the agencies.

The FLC also has an awards program. The FLC's annual awards, called "Awards for Excellence in Technology Transfer," honor laboratory scientists who have excelled at transferring their laboratory-developed technologies to the commercial marketplace and outside users. Additional awards honor laboratory directors and FLC members who have advanced the field of technology transfer and the FLC in the course of their work.

In addition, the FLC provides a number of information-sharing mechanisms. This includes newsletters, a web site, and a laboratory and technology locator service. The FLC's newsletters are the monthly *NewsLink*, which provides technology transfer and FLC news, and the quarterly *EduLink* on educational topics. The FLC's web site (www.federallabs.org) offers: a database search service organized according to laboratory missions and capabilities, pages devoted to policy and legislative issues, and the capability to submit on-line technology transfer requests to the Laboratory Locator service.

The FLC Laboratory Locator is a free service to help users locate federal laboratories with specialized expertise. Thus, it links potential public and private partners. The FLC maintains statistics on use of this locator service which indicate the number and type of requests, technology areas, and regional source (see Attachments 3a, 3b, and 3c.) The locator requests reveal four significant indicators of both technology transfer process and the FLC's role and impact:

- First, as more R&D funds have been provided over the years -- and as the FLC continues its mandate of facilitator between government, industry, and academia -- there has been a corresponding increase in locator requests from all of these entities.

- Second, the statistics also show that the requests vary in nature and type, including requests for government facility needs, technology needs, invention collaboration, licensing requests, SBIR partnerships and technology informational requests. The latter requests often lead to future collaborative efforts.

- Third, the statistics show that most of the requests fall into the country's critical technology areas including: biotechnology, manufacturing, automotive, environmental issues, electronics, sensors, materials, assistive technologies, and food processing.

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[1] Critical Technologies Institute. *New Forces at Work: Industry Views Critical Technologies*. Steven W. Popper, Caroline S. Wagner, Eric V. Larson. Supported by the Office of Science and Technology Policy.

These diverse interests, which parallel the nation's critical technology categories,[1] reflect the outreach of government to private industry and vice versa.

- The last statistic, requests by laboratory region, indicates a cross-section of the nation's participation in this valuable FLC tool. While each region shows participation in the Locator Service, the data provide the capability to examine success regionally, as well as identify those regions that may need additional training, support or publicity.

FLC Activities

Through mechanisms such as the FLC Locator service, the FLC works with industry and other outside users to identify problems and find solutions within the laboratory system. Through one example related to fire fighting, which I will describe here, the FLC is helping to save lives.

Following a tragic fire which killed three fire fighters, the NASA Langley Research Center signed an MOU with the Pittsburgh Bureau of Fire and the fire departments of other major metropolitan cities. In addition to the contribution of the FLC Locator Service, the FLC has supported this effort with only a small amount of funding (two $20,000 FLC demonstration project grants and co-sponsorship by the Mid-Atlantic Technology Applications Center, known as MTAC, in Pittsburgh). However, the effort has located laboratory technologies that are likely to be life savers.

First, as a result of the FLC/MTAC project, a technology that was designed for use by the Navy Seals is being licensed to manufacturers for use in fighting fires. The technology, which was developed at the Naval Coastal Systems Station in Panama City, Florida, allows communication by fire fighters in a high-noise environment. A high-tech microphone is placed in the headband of a fire fighter's helmet, and picks up skull vibrations caused by speaking. The vibrations are transformed into electric signals that are then fed into the firefighter's radio, thereby eliminating background noise. The helmet microphone was positively tested and evaluated at the Metropolitan Fire Chiefs Conference in 1998. Since then, several branches of the military have expressed interest in the invention as a direct result of the publicity surrounding the demonstration projects, as follows:

- The Marine Corps is testing the device in Kevlar ballistic helmets for the Urban Warrior program.

- The Shipboard Damage Control program of the Navy is in the process of evaluating the device this Spring.

- Eglin Air Force Base has expressed an interest in the device for their fire fighting units,

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Washington, D.C.: Rand. 1998.

and a demonstration was held for Tyndall AFB firefighters in April.

- The Army has entered into discussions with the Navy inventor concerning its use by ground troops.

- The Department of Defense is interested in integrating the communications system into their hazardous materials protective gear.

These leads, while still underway, show the promise for numerous dual uses for the technology.

In addition to the helmet technology, through the FLC/MTAC demonstration project, low-cost infrared imaging systems have been identified for use in fire fighting. And several other new technologies for monitoring fire fighters in buildings are being pursued.

Another activity resulting from the FLC/MTAC fire fighting demonstration project was a very successful meeting of the fire chiefs from the demonstration project's task force, along with representative from the federal laboratories, and university automotive engineering and human factors researchers. The Army's Aberdeen Proving Ground, in Aberdeen, Maryland, hosted the meeting which was held just last month. After spending the first day of the meeting touring the state-of-the-art Army fire testing and other facilities, they spent the second day identifying and prioritizing technology needs for fire fighting vehicles and developing a vehicle technology roadmap. During this process, the fire department officials shared their concerns about equipment, safety, lighting, weight, and other technology needs for the year 2010.

FLC Partnerships

In addition to the above services that the FLC provides, the organization has also entered into various partnerships to enhance the laboratories' ability to transfer technologies. One of these partnerships is called the TransAction Technology Group (TTG), and its objective is to lower U.S. defense procurement costs by promoting the commercialization of laboratory technologies. Besides the FLC, this partnership involves the U.S. Army Industrial Ecology Center (at Picatinny Arsenal, New Jersey); Concurrent Technologies Corporation (CTC) in Johnstown, Pennsylvania; and Unisphere Institute in Arlington, Virginia. The partnership initiative is performed under the National Defense Center for Environmental Excellence (NCDEE) operated by CTC. Picatinny Arsenal provides government oversight of the entire TTG program, and NDCEE provides overall coordination of the program, while Unisphere Institute specializes in helping technology-based companies enter new markets.

The partnering of these four organizations integrates the complex path that technologies take from an initial idea or concept, through development, testing and, ultimately, commercialization. Through this partnership, the following services are offered:

matching of an industry need with a laboratory technology; technology assessment; testing, verification and demonstration of the technology; market assessment; and deal structuring, negotiation, financing and closing; and business plan development.

The TTG partnership has established a “Laboratory Reimbursement Fund” to bridge an important gap in the commercialization process. The gap often occurs after the laboratory creates a technology, but before a company commits to utilize it. In order to license a technology or enter into a CRADA for further development, a company generally wants assurance that the technology will meet its specific needs. Obtaining such assurance may cost money that is unavailable and, as a result, the technology is not commercialized. For the current program year, $750,000 has been allocated to this fund which is structured to fill the gap where breakdowns often occur. The Laboratory Reimbursement Fund quickly and flexibly underwrites technology demonstration, testing, validation and enhancement activities that meet specific needs of private sector firms. Minimal paperwork and turn-around times are required for a funding decision.

Another partnership involving FLC participation was the “Technology Access for Product Innovation” (TAP-IN) program which operated from 1994 to 1996. TAP-IN was competitively selected through a national solicitation for proposals, and ended up being the largest technology deployment project funded by the Technology Reinvestment Project (TRP). TAP-IN helped companies access and apply defense technologies, and helped defense-dependent companies enter new commercial markets. In addition to the FLC, the TAP-IN partnership consisted of NASA’s six regional technology transfer centers (RTTCs), technology and business development organizations in every state, and the Industrial Designers Society of America.

Like the TTG partnership, TAP-IN provided expert assistance in all stages of the commercialization process from concept through prototype design to capital sourcing and marketing strategy. This included helping companies to locate new technology, identify business partners, secure financing, develop ideas for new products, identify new markets, license technology, solve technical problems, and develop company-specific applications of federal technology.

Through its involvement in TAP-IN, the FLC was also able to initiate a program called the “Reinvention Initiative Between Industry and Technology” (RIBIT). In this program, the FLC collaborated with the RTTCs to develop and implement a process for performing commercial assessments of defense technology.

Federal Laboratory Technology Transfer: Background

Recently in this country, there has been a shift in trends so that industry is investing more in R&D. It has become apparent that the private sector is more efficient in performing short-term R&D that is more product-oriented than the basic and applied research performed by the government. Companies generally do not invest in basic research because they do not have the required funds, time, or corporate memory.

Nevertheless, basic research is essential to the continuum comprising the technology development pipeline so that products emerge at the other end of the pipeline. Therefore, the private sector is coming to the government laboratories as an outlet for filling industry needs for basic research results. In order to feel comfortable entering into cooperative R&D agreements with the government, corporate America must feel secure that the longer-term government R&D programs will not suddenly be eliminated due to R&D budget cuts. Otherwise, companies will not feel secure in their CRADAs relationships, and the government will lose its partners.

Thus, government laboratories add value to the business environment by providing strength and continuity to the high-tech equation. In investing in long-term R&D, Congress is helping to foster the market-oriented aspects of that business environment and enabling competitive forces to operate. It is our demand-driven economy that ultimately pulls the technologies out into the marketplace.

Federal Laboratory Technology Transfer: Context

While the FLC initiates a variety of strategies and services on behalf of -- and in support of -- the federal technology transfer community, it does not own or license technologies. The FLC's member laboratories and agencies undertake these types of activities through technology transfer.

The United States is a leader in the area of technology transfer, as our legislation is being imitated in other countries. For instance, Japan is now implementing its own technology transfer laws and programs. So Congress has been forward-thinking in providing our existing laws in this area. (See Attachment 1 for a summary of existing technology transfer laws.) Now it is important for the nation to maintain its leadership role in international competitiveness.

This portion of my remarks will describe some of the mechanisms available to industry, universities, and other outside users interested in taking advantage of the expertise and technologies within the federal laboratory system. These mechanisms include not just licensing, a common form of technology transfer. They also include, for example, cooperative R&D agreements, reimbursable work and technical assistance, personnel exchanges, and consortia.

I will address licensing first. Licensing patents and patent applications has made technology transfer more productive. It has also helped federal laboratory staff members to recognize and support their inventions. Exclusive licensing does not inhibit the broad application of a technology. In many cases, the technology can be applied in different industrial sectors and markets.

Industry can also negotiate a Cooperative R&D Agreement (CRADA) or other such agreement (such as a Memoranda of Understanding, MOU) or other special authority.[2] Through CRADAs, companies (or groups of companies) can work with one or more federal laboratories to pool resources and share the risks of developing technologies. CRADAs are especially useful when the transfer of technology and the subsequent transfer of rights are expected to be important to the collaborating party.

Some federal laboratories have provisions for undertaking sponsored research. This involves industry reimbursing the laboratory for the cost of work done at the facility. In such cases, the work carried out must require unique capabilities that are not available in the private sector. The information acquired generally belongs to the sponsoring company.

Federal laboratories often provide industry with technical assistance regarding unique government expertise. Small businesses in particular benefit from technical assistance and suggestions from laboratory staff. Depending on the circumstances, there may be no charge for this assistance.

In the case of personnel exchanges, staff members from the private sector are assigned to government laboratories. Reverse assignments (in which government scientists work in industry) can also occur. In these situations, the employer pays its own staff salary costs, and the laboratory provides services and supplies.

It should be noted that federal laboratories can also work with outside partners through consortia which may involve the laboratories, universities, and industry all focusing on broad technologies cooperatively.

Finally, in addition to these mechanisms oriented toward non-federal users, there are also mechanisms for facilitating technology transfers between federal agencies. Inter-agency transfers serve to leverage the taxpayer's dollars by promoting multi-agency uses for technologies. This form of technology transfer is not well-documented on a government-wide basis, but anecdotal evidence indicates that inter-agency transfer is becoming more important to the agencies' missions and, consequently, more prominent.

Cautionary Note on R&D and Technology Transfer

In addition to well-endowed federal R&D programs, in terms of having an impact on the economy, we also need to make sure we have in place the necessary technology transfer mechanisms to facilitate getting technologies to the marketplace. Technology transfer should be an integral part of any R&D strategy, not just an afterthought. It is a way of accomplishing agency and laboratory missions by leveraging the initial R&D investment. The Department of Defense, for example, calls this "dual use." (I should add here, however, that we are very sensitive to the fact that some technologies are not open

[2] NASA's mandates to work with industry include both the 1958 Space Act and the President's National Space Policy of 1989. Under its authority, NASA enters into a variety of non-reimbursable or reimbursable agreements involving the use or exchange of facilities, equipment, information, expertise, intellectual property rights, or other resources.

for commercialization because they are militarily critical.)

Regardless of the differences among the agencies in implementing their technology transfer programs, there is one similarity among them. That is, the entire technology transfer process from technology development to commercialization is involving collaborative business transactions more and more. Technology transfer through partnerships is now a way of doing business. This way of doing business, in a collaborative mode rather than contentiously, is permeating the agencies' cultures. It includes not just those agencies that have traditionally worked closely with industry, but all the agencies. In that sense, the phrase "technology transfer" has taken on a new meaning; that is, technology is transferred between the parties – both ways – through collaboration.

In light of the public-private nature of technology transfer and commercialization, it is important to point out that it is not a subsidization program. Technology transfer transactions and deals must benefit the agencies' missions and must bring in some sort of returns to the agencies, such as royalties or other funds and forms of leverage. The agencies are looking for qualified partners. There is no free ride! Because companies are being brought into the technology development process towards the end of the continuum, the agencies must screen the candidates for the best ones -- or the original R&D investment will be wasted.

Measuring Performance and Success

The bottom line of this discussion is that technology transfer is not just valuable, but vital, for the nation's future. Technology transfer programs make sense since the risks are shared, as well as benefits and the resulting success stories. Many successes of the past are well documented. They show contributions to the economy as well as non-quantifiable contributions to the betterment of mankind.

In our technology transfer community, we are just beginning to define success and identify proper performance measures and estimate our impact. With this statement, I am speaking on behalf of both the FLC as an institution and its members in the agencies and their laboratories. The FLC acknowledges its responsibility as an organization to comply with the Government Performance and Results Act (GPRA). In addition to developing its strategic plan -- which contains many good examples of performance measures -- the FLC is presently devising outcome measures in accordance with GPRA's requirements.

The FLC and its members agree that assessing the value of technology transfer to all participants is a high-priority issue in our community. For one thing, since the use of taxpayer money is involved, it is of paramount importance to be able to understand federal performance. There are many other reasons for measurement and evaluation efforts. For the agencies and laboratories, certain measures are useful for making comparisons among the laboratories or across agencies, or for tracking progress over time within a single facility. Technology transfer measures are also needed by laboratory managers so that they can know how they are doing and adjust their performance before being judged by external or stakeholder standards. This is particularly important when being required to adopt new ways of doing business. Measures help to gauge the rate of improvement in the technology transfer process and to provide guidance on how that process might be enhanced.

However, in spite of best efforts, technology transfer evaluation continues to be problematic. In particular, the long-term nature of technology development and the volatility of technology contribute to the difficulties of precisely measuring technology transfer. Also, measurement is currently a difficult process for the laboratories because technology transfer activities must relate to the laboratory missions which are continually being re-examined and often in a state of flux. In addition, due to the wide array of approaches to transferring technologies among the federal departments and agencies that I noted earlier, we need to identify measures that can be used across a wide range of technology transfer approaches. Consider for a moment the task of comparing, for example, the personnel exchange program of a government-owned, contractor-operated (GOCO) laboratory with a CRADA between a government-owned, government-operated (GOGO) laboratory and a large company. Or consider comparing the provision of technical assistance to a small local firm versus licensing a patent to a large international firm.

Furthermore, the complex nature of the technology commercialization process with its multiple actors makes evaluation difficult. An FLC guidebook states, "Value may be added at each of the many steps from the laboratory to marketing of a commercial product. It would be difficult to determine what portion of the value to assign to the underlying technology. Companies are not accustomed to making such measures, let alone publicizing them. More importantly, such measures are not available until a new technology is incorporated into a marketable product, which may be years hence . . .Only with technical assistance programs can the value to the private sector ever be estimated quickly."[1]

Earlier, I described cultural changes that are occurring in the agencies as a result of technology transfer. But how do we know whether cultural change is really taking place, both in the government and in the private sector? Indicators of cultural trends and process changes in this area can serve as indicators of technology transfer progress. Yet indicators of cultural change are, by nature, less quantitative than other measures. They apply to personnel practices (use of performance evaluation criteria, rewards, training), organizational structure (positioning of technology officer and other outreach staff), and intellectual property issues (protection of intellectual property, foreign patent policies, licensing practices), among others. Also, like other aspects of technology transfer, they

[1] *Technology Transition in a Time of Transition: A Guide to Defense Conversion,* Prepared by: The Federal Laboratory Consortium for Technology Transfer, Beverly J. Berger, Ph.D., Washington, D.C. Representative, Washington, D.C., Federal Laboratory Consortium Special Reports Series No. 3, ISSN 1075-9492, August 1994.

can only be detected in the long run.

Finally, there is no clear agreement as to which indicators comprise activity measures (of output) or outcome measures. Measures of output of technology transfer and of quantifiable technology transfer activities are commonplace. Output is commonly measured in terms of the number of jobs created, number of new companies formed, and increases in company revenues, profits, market shares, and productivity. In both the government and industry, we can also tally the number of patents issued. These indicators can provide quantifiable measures of technology transfer, when obtainable -- as private companies are often not willing to share proprietary and confidential data.

Theoretically, the laboratories are able to track the number of invention disclosures, patents filed, patents issued, licensing agreements, CRADAs, and personnel exchanges, and the amount of licensing income. These measures are most useful on a per capita basis, based upon the numbers of scientists and engineers at each laboratory. However, they are not often reported that way -- or even in a comparable, uniform format.

Currently, no federal organization collects this type of information annually for all agencies. The Department of Commerce is required to collect certain government technology transfer data on a biennial basis – a major undertaking because the data is inconsistent among the departments and agencies which makes it very difficult to make useful comparisons. The Commerce Department is currently finalizing its data for another report to Congress in its series.

According to Commerce Department staff, preliminary data indicate that the growth of federal laboratory licensing revenues over the years is comparable to the findings by the Association of University Technology Managers (AUTM) for the university community – or roughly 20 percent compounded over time. The National Institutes of Health, for example, has extensive experience in licensing and is the most financially successful federal entity in that regard. NIH's royalty income in FY 1998 increased by 47 percent over the FY 1996, from $27 million to almost $40 million.[1] For FY 1998, this represents more than two-thirds of the royalty income generated by the entire federal government. Over the past two years, NIH increased its number of executed licenses by 17 percent from 184 in FY 1996 to 215 in FY 1998 raising the number of active licenses to an all-time high of 1,039.

CRADAs were first enabled by 1986 legislation. At a minimum, the number of CRADAs provides an activity measure, and there is no question that the number of CRADAs has increased over time. It is documented that through FY 1988, there were about a hundred CRADAs. Ten years later, unofficial counts indicate that over 5,000 CRADAs have been executed. Throughout the same decade, however, the usefulness of this measure calculated over time is somewhat erratic since some departments have

[1] Biennial Report of the Director, National Institutes of Health, FY 1997-1998 (March 11, 1999 Draft).

offered special funding for the government portion of CRADA activity in some years and not in other years.

It has been suggested that another less common but simple measure to track would be the percent of time laboratory scientists spend on technology transfer. Yet this indicator provides an example of how measuring the process of technology transfer may inadvertently impede it at the same time. In 1994, the FLC wrote, "Many believe that federal laboratories will contribute far more to the American economy as a consequence of informal interactions with American companies than through all the CRADAs and PLAs [patent licensing agreements] that will ever exist. If this is true, then the greatest need is for measures that are designed to increase these informal relationships. Direct measurement of these relationships would inhibit them; requirements for records of every contact between laboratory employees and the private sector could only discourage those contacts. The objective must be to change the culture of federal laboratories and private companies such that collaboration is customary and frequent."

In summary, speaking on behalf of both the FLC and the agencies, I must say that that our efforts to measure and evaluate are still in progress. We are not at the end of our journey.

<u>Examples of Success Stories</u>

The now-completed TAP-IN partnership was instrumental in developing a process for drawing the technologies out of laboratories and government agencies, singling out the strongest, and laying the foundation for their commercial development. The program succeeded in accomplishing its objectives in spite of many obstacles encountered and the short duration of the program. In short, TAP-IN helped more than 3,000 small defense firms enter new markets and introduce new commercial products and assisted more than 3,400 industry and laboratory clients in commercializing defense-related technologies during its two and one-half years of operation.

Examples of projected sales and job creation for the companies assisted through TAP-IN illustrates the long-term nature of technology transfer, and the difficulty of measuring in the short-term while the commercialization process is still underway. For example:

- An improved casting and machining operation projects a 40 percent increase in sales;

- A new cancer detection system is projected to result in a $200 million market share over five years;

- A new muscular therapy product is projected to result in $10 million annually in the U.S.;

- A high-temperature sensor is projected to result in a 2-3 percent market share of a $1 billion market; and

- The market share for a defense contractor diversifying into the commercial fiber optics markets is projected to double.

The RIBIT partnership provided market information on defense technologies critical to their successful commercial development. Federal laboratories across the country nominated more than 400 technologies believed to have commercial potential. Market asssessment analysts from the RTTCs reviewed each technology and selected more than 100 to evaluate in greater depth. The team then selected the twelve most promising technologies for a focused commercialization effort. In 1996, the FLC published a document of technologies assessed through the RIBIT network. This publication highlights the twelve “best-bets” out of 433 technologies. It also includes 25 “go-ahead” technologies available for business commercialization. Due to the success of the RIBIT program, a second round of the program was recently implemented.

At the National Institutes of Health (NIH), the ultimate goal is for NIH technologies to benefit the patient. In 1998 alone, the Food and Drug Administration (FDA) approved for use six NIH technologies licensed to companies. This is the largest number of NIH-related products that has ever been approved in a single year. The products and technologies are:

- Synagis, a monoclonal antibody for the prevention and treatment of serious lower respiratory syncytial virus (RSV), was developed by Medimmune, Inc.;

- Certiva, a combined diphtheria, tetanus and acellular pertussis vaccine for infants and children, was developed by North American Vaccine, Inc.;

- Vitravene, a phosphorothioate oglionucliotide that inhibits cytomegalovirus (CMV) infections in the eye, was developed by Isis Pharmaceuticals, Inc. and is the first antisense therapeutic approved for use in humans;

- RotaShield, a live oral vaccine for the prevention of rotavirus gastroenteritis in infants, was developed by Wyeth Laboratories, Inc. and is the first rotavirus vaccine approved for use in humans;

- AcuTect, a synthetic peptide radiopharmaceutical used for the detection of acute deep venous thrombosis (DVT), the most common source of pulmonary embolism, was developed by Diatide Inc. AcuTect is the first in-vivo imaging agent to target acute DVT in the lower extremities; and

- Thyrogen, a recombinant form of human thyroid stimulating hormone (TSH) for use in the follow-up screening of patients who have been treated for thyroid cancer. Thyrogen was developed by Genzyme Corporation.

NASA provides a good example of agency and its laboratory technology transfer results. During the past four decades, a wide-ranging array of R&D activities has been conducted by NASA. They continue to provide large volumes of scientific and technical information. And each year, hundreds of transferable new technologies have resulted from such efforts. The taxpayers' investment has been immense, but the benefits returned to mankind even larger. Although NASA's budget has decreased, its R&D efforts continue to produce sophisticated technologies ready for application in the development of commercial products. Thus, industry does profit from the agency's Commercial Technology Program with its array of services geared to assist in maintaining global competitiveness.

So it is established that outreach activities and partnerships between NASA field centers and outside engineers have created many new "spinoffs." The following are only a few examples that highlight the work of NASA's Commercial Technology Network.

The Kennedy Space Center (KSC) and the state of Florida have a technology outreach program that helps Florida businesses solve technical problems. The Technological Research and Development Authority (TDRA) was established in 1987 by the Florida legislature. KSC and TRDA, working together, have been able to transfer space technology expertise to private industry needs. As a result, many problem-solving ideas have come forward. These include:

- making ink dry faster in the manufacturing of American flags,
- improving the fit of a prosthetic foot,
- identifying a low-cost, hand-held carbon monoxide detector for fire fighters, and
- reducing the noise and vibration of a dental drill.

NASA's KSC has come to the assistance of hundreds and hundreds of Florida companies over the past few years. In one case, a Rockledge, Florida company that makes high-speed electric motors was plagued by bearings breaking down at high speed. NASA identified an improved bearing design and materials that would result in longer-lasting performance. In another case, a Cape Coral, Florida manufacturer of an oxygen device for home use had a problem with its equipment. KSC engineers tested the malfunctioning device, identified the source of the problem, and initiated the solution.

Technology from NASA's Ames Research Center in Iowa was installed at the Denver International Airport. The airport's primary traffic management tool features an air traffic control automation system developed at Ames in the late 1980s. Denver airport officials say their air traffic management systems have been operating very smoothly and efficiently with this technology.

Another NASA success story involved a young woman diagnosed with a rare disease, and whose only method for communicating was through a computer switch activated with her mouth which allowed her to select from an array of words. The switch under her chin, however, was cumbersome and difficult to use. This problem was addressed by NASA's Langley Research Center in Virginia where engineers crafted a custom headpiece involving a "chin mouse" so that her chin could activate a microswitch, thereby improving her quality of life.

NASA's network comprised of its field centers and other facilities provides just one example of an agency that stands ready to partner with U.S. businesses to improve the productivity and competitiveness of American industry.

As I noted earlier, every year, the FLC carries out an important awards program. Next week, at the 25th anniversary conference for the FLC, we will be presenting a series of awards to laboratory researchers for technologies that significantly impact the quality of our lives and the nation's economy (see Attachment 4). I will summarize several of those awards here.

A new technology developed at the FDA's National Center for Toxicological Research in Arkansas provides a simple, inexpensive, quick, and effective device for determining the quality of food products. The device can be packaged with food stored in typical conditions and can be built into food packaging to verify freshness without opening the package or thawing the product. It works for fish, shrimp, milk, and red meat and, with modifications, can be used for any food product containing protein. Cox Recorders received a license to manufacture products based on the technology under the trade name Fresh Tag™. The award recipients are now working with researchers at the University of Florida to validate specialized versions of the indicator that can quickly assess the quality of frozen or fresh shrimp at dockside, a major challenge faced by the food industry. Once it becomes industry standard, annual sales for the U.S. seafood industry alone should approximate $100 million.

Researchers at an Agricultural Research Service laboratory invented and transferred the first U.S. vaccine that protects channel catfish from a disease which costs the U.S. aqua-culture industry $50 million annually. The Alabama Catfish Producers supported the vaccine development through a CRADA. Another CRADA with InterVet, Inc. further developed the vaccine's properties and resulted in a license to manufacture and market the vaccine in the United States. The vaccine is expected to reduce the cost of the disease by $30 to $40 million annually for the $890 million U.S. aqua-culture industry.

At another agricultural laboratory, researchers developed and transferred technologies that reduce aflatoxin levels in commercial pistachios. Aflatoxin is a potential human carcinogen, so in order to export pistachios to Europe, U.S. producers must meet aflatoxin levels five times lower than in the U.S. The researchers developed a sophisticated image sorter that virtually eliminates aflatoxin through real-time sorting in processing plants. The device was licensed and targeted for commercialization late last year. This work has helped to increase sales of U.S. pistachios to Europe by more than $40 million in the last three years.

A researcher at the U.S. Naval Research Laboratory in Washington, D.C.

pioneered the development of novel liquid crystal display (LCD) materials for advanced optical display devices and information processing. He also successfully transferred the technologies to the commercial and military sectors. A CRADA with Shipley Company was so successful that it was extended twice; under the most recent extension, Shipley was granted a partially exclusive right and license to practice three of the inventions in the field of LCD manufacturing. The laboratory also entered into a CRADA with Opticom USA, and this CRADA was recently amended to focus on commercialization. Commercial applications of the technologies include flat panel displays of all kinds. They are expected to significantly affect the $22 billion LCD industry. The technologies could replace the traditional process in existing manufacturing lines, and may open new lines.

In another example, a cost-cutting bioprocess developed by a researcher at Argonne National Laboratory in Illinois means that millions of pounds of toxic industrial solvents could soon be replaced by an environmentally friendly solvent made from agricultural feedstocks. The “green” solvent ethyl lactate has been used commercially since the 1980s; however, the price of $1.60 to $2 per pound did not allow for large-scale substitution of toxic solvents. By developing new purification methods, the laboratory solved fundamental technical issues and reduced the selling price of ethyl lactate to less than $1 per pound. Working with a small business industrial partner, NTEC Versol, Inc., the laboratory researcher transferred the technology, which has been licensed and is now being commercialized. The alliance also resulted in a start-up company, NTEC EDSep, Inc., that is working with industrial clients to solve industrial pollution prevention issues using electrodialysis.

A new medical device developed by researchers at Lawrence Livermore National Laboratory in California improves the treatment of cerebral aneurysms and hemorrhagic stroke. Cerebral aneurysms are particularly dangerous because they can lead to stroke, brain damage, or death. More than 100,000 people suffer from hemorraghic strokes each year, with 50 percent proving fatal. The transferred technology is a coil-release device that safely permits coils to be positioned and released inside cerebral aneurysms. A fiber optic carries laser energy to a light-activated polymer that releases the metallic coil in less than a second. The device automatically detects the coil release and provides doctors with immediate feedback, an improvement over previous commercial systems which took 5 to 15 minutes per coil, resulting in prolonged treatment times. The cross-disciplinary LLNL team developed the technology, demonstrating proof-of-concept, and assisted with the regulations process, user interface, and reliability and safety issues. The team’s work was guided by a stroke summit held at the laboratory in the mid-1990s, which highlighted the need for an improved device. Micrus, Inc. licensed the technology and is now developing it for commercialization. The device’s potential to save lives, prevent serious disability, and improve lifetime productivity will reduce the taxpayer burden caused by strokes and help to lower health-care costs.

Again, the awards listed above provide just several examples from this year’s FLC awards for technology transfer excellence. Every year, the FLC honors many such scientists. They represent the vast potential of the scientific expertise that resides throughout our federal laboratory system.

Technology Transfer: Refinements Needed

To address the subject of this hearing, the nation's R&D investment, I would like to point out that if we make more of an investment in R&D, then some of that investment should be applied to the technology commercialization process, broadly. This would help provide more of an underpinning to what is currently an unfunded mandate for many (although not all) agencies to transfer technologies. I should add that the need for more resources to perform technology transfer is not an across-the-board need, since the agencies differ – sometimes dramatically – in their approaches to technology transfer. For example, NASA accomplishes and supports its technology commercialization program quite differently from the military services.

We stated that technology transfer inherently involves business strategies, and there is a growing recognition of this business aspect of technology transfer. However, these business transactions need to be further recognized and rewarded. For example, our laws state that technology transfer is supposed to be a part of each agency's position descriptions. However, few agencies have been rigorous in adhering to this provision. Similarly, some agency technology transfer programs are in a state of transition or are experiencing declining resources for business support services such as legal staff. Consequently, it takes longer to obtain legal advice that is so necessary in technology commercialization. These conditions also create an uncertain environment for adequate enforcement of legal agreements signed by the agencies. So we are looking to the agencies to make judicious staffing and allocation decisions. We are looking to Congress to provide oversight of these agency programs.

The last point I want to make is that time is becoming an all-important factor in technology commercialization. This means that it will benefit industry to have the proper tools – such as cooperative R&D agreements (CRADAs) and related intellectual property protection – so that there are fewer hurdles to straddle on their route to the marketplace. Our ability to offer tools that are sensitive to the time factor will be answered by the Technology Transfer Commercialization bill that has been carefully making its way through Congress in the past year. We look forward to its passage in the very near future.

The nation's laws regarding technology transfer and commercialization are working and – with some anticipated refinements – will serve us long into the future. However, one technology area may necessitate further investigation in terms of the need for further legislation. The issue is that U.S. law prohibits federal laboratory employees from directly copyrighting software, although they may protect software-related inventions by patent. (As an aside, there have been cases where companies have entered CRADAs with federal software developers, and have made such significant contributions or changes to the software that the company has been able to copyright the product resulting from the CRADA.) In short, this issue points out that incentives to commercialize software may be lacking. Our community has not arrived at a consensus on this issue so we continue to raise awareness in this area and to explore the alternatives.

Summary and Closing

Over the years we can see that a number of our federal technologies have been transferred and developed to greatly improve our lives. We see these in products for sports and recreation (aerodynamic golf balls), and in consumer products (Thirsty Starch and Memory Metal), and in new diagnostic methods for better health and medicine (more accurate mammograms).

Continued and enhanced support for the R&D performed at our federal laboratories is necessary for the generation of new ideas that U.S. companies need for developing products. Through technology transfer activities, there is an environment for industry, academia, and our federal laboratories to develop technologies that significantly impact the quality of our lives and contribute to the U.S. economy. Today, we have a much-improved technological climate, along with increased interest and awareness in new technologies, and the proper mechanisms for transferring technology. Next year, the globe enters a new millennium filled with promise and challenges. With a healthy investment in R&D, the future for technologies will be bright for the new millennium. This will contribute the essential raw ingredients for successful technology transfer, while contributing to America's competitiveness in the global marketplace.

List of Attachments

1 - Technology Transfer Legislation Highlights

2 – FLC Vision, Mission, Goals and Objectives, and Strategies

3 – FLC Laboratory Locator Service statistics:
- 3a – Requests by Type
- 3b – Requests by Category
- 3c – Requests by Region

4 - FLC 1999 Awards for Technology Transfer Excellence

Attachment 1

Technology Innovation Legislation Highlights

Prepared by the FLC

Stevenson-Wydler Technology Innovation Act of 1980 (Public Law 96-480)

- Focused on dissemination of information.
- Required federal laboratories to take an active role in technical cooperation.
- Established Offices of Research and Technology Application at major federal laboratories.
- Established the Center for the Utilization of Federal Technology (in the National Technical Information Service).

Bayh-Dole Act of 1980 (Public Law 96-517)

- Permitted universities, not for profits, and small businesses to obtain title to inventions developed with governmental support.
- Allowed government-owned, government-operated (GOGO) laboratories to grant exclusive licenses to patents.

Small Business Innovation Development Act of 1982 (Public Law 97-219)

- Required agencies to provide special funds for small business R&D connected to the agencies' missions.

Cooperative Research Act of 1984 (Public Law 98-462)

- Eliminated treble damage aspect of antitrust concerns for companies wishing to pool research resources and engage in joint, precompetitive R&D.
- Resulted in Consortia: Semiconductor Research Corporation (SRC) and Microelectronics and Computer Technology Corporation (MCC), among others.

Trademark Clarification Act of 1984 (Public Law 98-620)

- Permitted decisions to be made at the laboratory level in government-owned, contractor-operated (GOCO) laboratories as to the awarding of licenses for patents.
- Permitted contractors to receive patent royalties for use in R&D, awards, or for education.
- Permitted private companies, regardless of size, to obtain exclusive licenses.
- Permitted laboratories run by universities and non-profit institutions to retain title to inventions within limitations.

Japanese Technical Literature Act of 1986 (Public Law 99-382)

- Improved the availability of Japanese science and engineering literature in the U.S.

Federal Technology Transfer Act of 1986 (Public Law 99-502)

- Made technology transfer a responsibility of all federal laboratory scientists and engineers.
- Mandated that technology transfer responsibility be considered in laboratory employee performance evaluations.
- Established principle of royalty sharing for federal inventors (15% minimum) and set up a reward system for other innovators.
- Legislated a charter for Federal Laboratory Consortium for Technology Transfer and provided a funding mechanism for that organization to carry out its work.
- Provided specific requirements, incentives and authorities for the federal laboratories.
- Empowered each agency to give the director of GOGO laboratories authority to enter into cooperative R&D agreements and negotiate licensing agreements with streamlined headquarters review.
- Allowed laboratories to make advance agreements with large and small companies on title and license to inventions resulting from Cooperative R&D Agreements (CRADAS) with government laboratories.
- Allowed directors of GOGO laboratories to negotiate licensing agreements for inventions made at their laboratories.
- Provided for exchanging GOGO laboratory personnel, services, and equipment with their research partners.
- Made it possible to grant and waive rights to GOGO laboratory inventions and intellectual property.
- Allowed current and former federal employees to participate in commercial development, to the extent there is no conflict of interest.

Malcom Baldrige National Quality Improvement Act of 1987 (Public Law 100-107)

- Established categories and criteria for the Malcom Baldrige National Quality Award.

Executive Orders 12591 and 12618 (1987): Facilitating Access to Science and Technology

- Promoted access to science and technology.

Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418)

- Placed emphasis on the need for public/private cooperation on assuring full use of results of research.
- Established centers for transferring manufacturing technology.
- Established Industrial Extension Services within states and an information clearinghouse on successful state and local technology programs.
- Changed the name of the National Bureau of Standards to the National Institute of Standards and Technology and broadened its technology transfer role.
- Extended royalty payment requirements to non-government employees of federal laboratories.
- Authorized Training Technology Transfer centers administered by the Department of

Education.

National Institute of Standards and Technology Authorization Act for FY 1989 (Public Law 100-519)

- Established a Technology Administration within the Department of Commerce.
- Permitted contractual consideration for rights to intellectual property other than patents in CRADAS.
- Included software development contributors eligible for awards.
- Clarified the rights of guest worker inventors regarding royalties.

Water Resources Development Act of 1988 (Public Law 100-676)

- Authorized Army Corps of Engineers laboratories and research centers to enter into cooperative research and development agreements.
- Allowed the Corps to fund up to 50% of the cost of the cooperative project.

National Competitiveness Technology Transfer Act of 1989 (Public Law 101-189)

(included as Section 3131 et seq. of DOD Authorization Act for FY 1990)

- Granted GOCO federal laboratories opportunities to enter into CRADAs and other activities with universities and private industry, in essentially the same ways as highlighted under the Federal Technology Transfer Act of 1986.
- Allowed information and innovations brought into, and created through, CRADAs to be protected from disclosure.
- Provided a technology transfer mission for the nuclear weapons laboratories.

Defense Authorization Act for FY 1991 (Public Law 101-510)

- Established model programs for national defense laboratories to demonstrate successful relationships between federal government, state and local governments, and small business.
- Provided for a federal laboratory to enter into a contract or memorandum of understanding with a partnership intermediary to perform services related to cooperative or joint activities with small business.
- Provided for development and implementation of a National Defense Manufacturing Technology Plan.

Intermodal Surface Transportation Efficiency Act of 1991 (Public Law 102-240)

- Authorized the Department of Transportation to provide not more than 50% of the cost of CRADAs for highway research and development.
- Encouraged innovative solutions to highway problems and stimulated the marketing of new technologies on a cost shared basis of more than 50% if there is substantial public interest or benefit.

American Technology Preeminence Act of 1991 (Public Law 102-245)

- Extended FLC mandate, removed FLC responsibility for conducting a grant program, and required the inclusion of the results of an independent annual audit in the FLC Annual Report to Congress and the President.
- Included intellectual property as potential contributions under CRADAs.
- Required the Secretary of Commerce to report on the advisability of authorizing a new form of CRADA that permits federal contributions of funds.
- Allowed laboratory directors to give excess equipment to educational institutions and nonprofit organizations as a gift.

Small Business Technology Transfer Act of 1992 (Public Law 102-564)

- Established a three-year pilot program, the Small Business Technology Transfer (STTR) program, at DOD, DOE, HHS, NASA, and NSF.
- Directed the Small Business Administration (SBA) to oversee and coordinate the implementation of the STTR program.
- Designed the STTR similar to the Small Business Innovation Research (SBIR) program.
- Required each of the five agencies to fund cooperative R&D projects involving a small company and a researcher at a university, federally-funded research and development center, or nonprofit research institution.

National Department of Defense Authorization Act for 1993 (Public Law 102-25)

- Facilitated and encouraged technology transfer to small businesses.

National Defense Authorization Act for FY 1993 (Public Law 102-484)

- Extended the streamlining of small business technology transfer procedures for non-federal laboratory contractors.
- Directed DOE to issue guidelines to facilitate technology transfer to small businesses.
- Extended the potential for CRADAs to some DOD-funded Federally Funded Research and Development Centers (FFRDCs) not owned by the government.

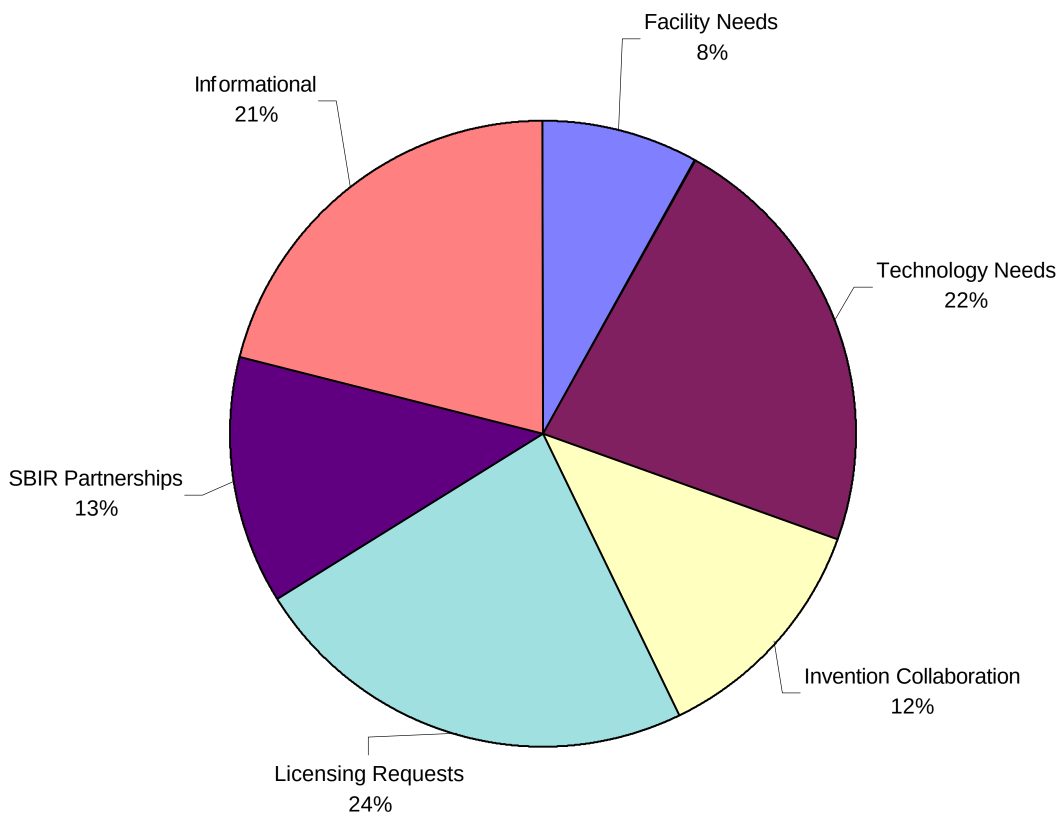
National Department of Defense Authorization Act for 1994 (Public Law 103-160)

- Broadened the definition of a laboratory to include weapons production facilities of the DOE.

A full copy of Technology Innovation may be ordered from the Federal Laboratory Consortium MSO, 950 N. Kings Highway, Suite 208, Cherry Hill, NJ 08034, or telephone (609) 667-7727.

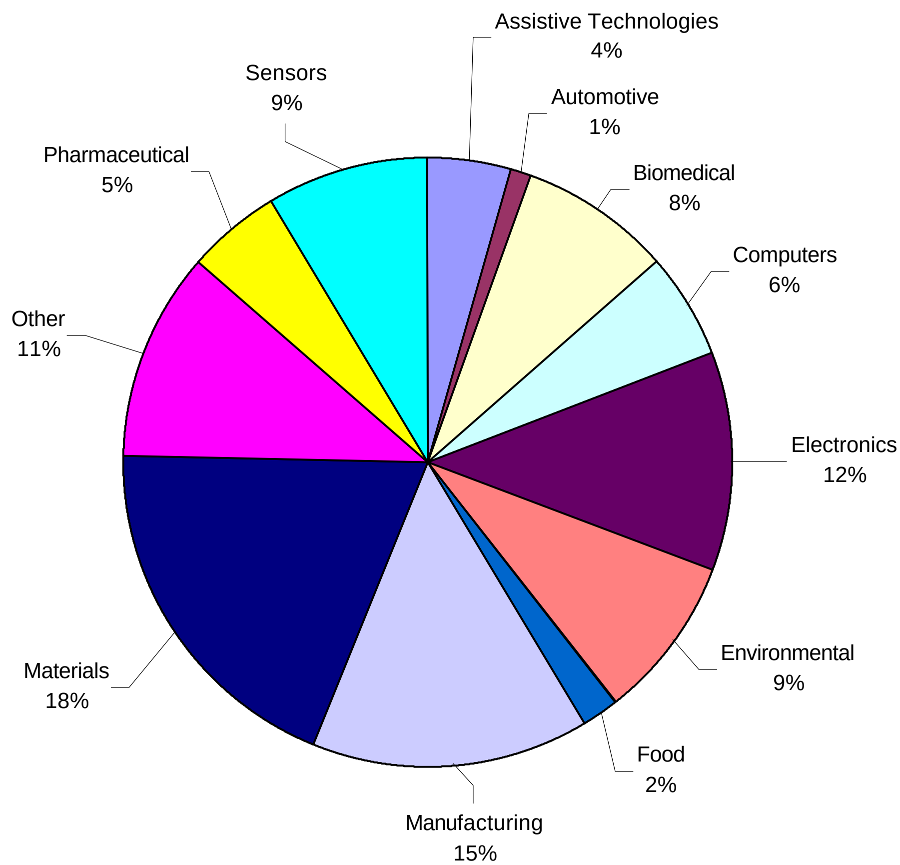
Attachment 3a

FLC Locator - Requests by Type



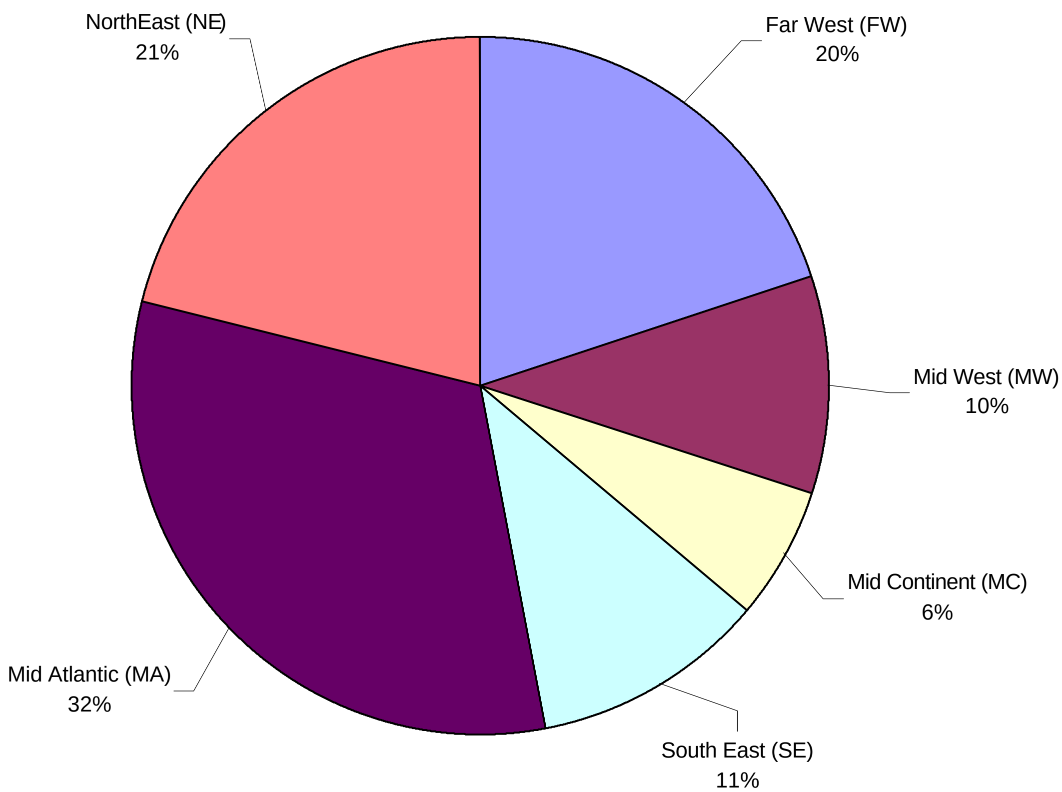
Attachment 3b

FLC Locator - Requests by Category



Attachment 3c

FLC Locator - Requests by Region



Attachment 4

FLC 1999 Awards for Technology Transfer Excellence

Modified Live-Fish Vaccine Prevents Major Bacterial Disease of Channel Catfish

USDA-Agricultural Research Service (ARS) Mid South Area-Fish Diseases and Parasites Research Laboratory

The recipients invented and transferred the first U.S. vaccine that protects channel catfish from enteric septicemia of catfish (ESC)—a disease that costs the U.S. aqua-culture industry $50 million annually. The vaccine significantly reduces the use of antibiotics and other therapeutics considered harmful to the environment and animal food chain.

The Alabama Catfish Producers supported the vaccine development through a Cooperative Research and Development Agreement (CRADA). Another CRADA with InterVet, Inc. further developed the vaccine's properties and resulted in a license to manufacture and market the vaccine in the U.S.

The vaccine is expected to reduce the cost of ESC by $30 to $40 million annually for the $890 million U.S. industry.

Techniques for Reducing Aflatoxin in Pistachios Increase U.S. Share of European Market

USDA-ARS Pacific West Area-Western Regional Research Center

A naturally occurring plant contaminant, aflatoxin is a potential human carcinogen. To export pistachios to Europe, U.S. producers must meet aflatoxin levels five times lower than in the U.S.

The award recipients developed and transferred technologies that reduce aflatoxin levels in commercial pistachios. They first determined that 90% of aflatoxin could be eliminated by using an existing mechanical color-sorting technology. They then developed a sophisticated image sorter that virtually eliminates aflatoxin through real-time sorting in processing plants. The image sorter was licensed and targeted for commercialization in late 1998.

Their work has helped to increase sales of U.S. pistachios to Europe by more than $40 million in the last three years.

Insect-Trap Technology Detects Fruit Flies that Damage Crops

USDA-ARS South Atlantic Area-Center for Medical, Agricultural, and Veterinary Entomology

Robert Heath developed a new and highly sensitive insect attractant that detects and suppresses many varieties of fruit flies that threaten U.S. agriculture. Although the U.S. imposes strict quarantine on fruit flies, Florida and California have spent millions of dollars to control and keep fruit flies out of their states. Because eradication is extremely expensive and use of the insecticide Malathion is environmentally undesirable, early detection is critical.

Two CRADAs were instrumental in developing and licensing the technology. CONSEP® has a worldwide market and is selling the attractants under the trademark BioLure®, and PLATO Industries is licensed to make the attractants for "attract and kill" stations. Through the transfer of this technology, Heath has helped focus worldwide attention on this issue.

Immunological Reagents and Coccidial Vaccine Delivery Technologies Benefit Poultry Industry

USDA-Immunology and Disease Resistance Laboratory-Livestock and Poultry Sciences Institute

Dr. Hyun Lillehoj transferred three technologies to the poultry industry that enable it to monitor the protective immunity of chickens and develop novel vaccination strategies against avian viral, bacterial, and parasitic diseases.

One of her patented technologies was licensed to Chemicon International, Inc. and Serotec Ltd. and has been available commercially worldwide for eight years. Two other patent applications are underway, and tech transfer efforts in these areas have resulted in two CRADAs and two TRUST agreements with poultry and biotech companies to develop novel anti-coccidia control strategies.

Dr. Lillehoj's efforts opened new lines of communication between the public and private sectors to explore further commercial application of these technologies. Her accomplishments enable the poultry industry to more precisely evaluate vaccine responses and monitor resistance and protection against other diseases —thereby enhancing productivity and improving food safety.

Software Optimizes Microelectronics Packaging

DOC-National Institute of Standards and Technology (NIST)-Materials Science and Engineering Laboratory

The Solder Interconnect Design Team (SIDT) developed technology that helps microelectronics manufacturers select electronic component geometries and assembly processes that minimize the probability of short/open circuits forming during assembly and predict the reliability of the resulting solder joints.

The team provided public domain software that predicts the geometry of small-scale solder joints with a wide range of starting configurations. They then transferred these results to other models to improve product reliability and developed a set of presolved common solder joint design problems that can be modified for specific products. These tools are available through the SIDT web site, which also provides a discussion forum.

The technology transfer occurred through SIDT, which is an industry/government/university collaboration. The industrial partners—DEC, Motorola, BOC Gases, Ford, Lucent Technologies, AMP, Rockwell, Delco, and Texas Instruments—were brought together by NIST—along with 10 universities, Sandia National Laboratories, and Edison Welding Institute.

As a result of SIDT's technology, electronic devices can be made smaller, lighter, cheaper, and more durable.

Highly Reliable Heterojunction Bipolar Transistor (HBT) Circuits Result in Dual-Use Applications

DOD-Air Force-Air Force Research Laboratory (AFRL)

The team transferred AFRL's patented thermally-shunted heterojunction bipolar transistor (TSHBT) technology to Northrop Grumman's Electronic Sensors and Systems Division. TSHBT is a high-performance electronic device that has state-of-the-art performance for microwave power amplification. The device allows large power devices to be made smaller with less heat dissipation—thereby saving space and energy.

Numerous companies actively sought information and collaboration to benefit from the team's work. Efforts with Lockheed Martin, Hughes, Epitronics Corporation, Motorola, MA/COM, and M-Pulse ranged from information exchanges to working side-by-side to learn the detailed fabrication process.

Eventual recipients of the technology include various military systems and commercial markets such as cellular communications, direct satellite broadcasts, cable television base stations, and collision avoidance radar. One of the most tangible benefits is a simpler and cheaper design and longer operating times for cell phones.

Performance-Enhancing Refrigerant Additive Reduces Energy Consumption

DOD-Air Force-AFRL, Propulsion Directorate

QwikBoost—a recent AFRL spin-off—is a low-cost refrigerant additive that increases the performance of air conditioners, heat pumps, refrigerators, and freezers using new, environmentally friendly, hydrofluorocarbon (HFC) refrigerants. Mainstream Engineering Corporation developed QwikBoost under an Air Force Phase II SBIR program.

A single application of QwikBoost increases cooling performance for the life of the system and reduces wear on the compressor—typically enhancing performance by 10% to 20%.

Mr. Gottschlich's efforts in transferring this technology to a commercial product included forming an interagency heat pump working group with representatives from NASA, the Army, and the Air Force. At one of the group's meetings, he learned of a hybrid cycle heat pump being developed at NASA. He obtained additional funding for the effort and used the SBIR program to put the technology on contract in a timely manner. With his persistence and creativity, the technology went from a promising concept to commercial product within three years. QwikBoost, which became available for auto air conditioners in early 1998, should debut in home appliances by 2000. The product will reduce heating and cooling costs by 10% to 20% while saving billions of dollars in energy costs per year.

Adaptation of Intermediate Moisture Food Technology Produces Shelf-Stable, Ready-to-Eat Sandwich-Type Items

DOD-Army-U.S. Army Soldier Systems Command (SSCOM)-Natick RD&E Center (NRDEC) - Sustainability Directorate-Ration Systems Division - Ration Development Branch

The team achieved a technical breakthrough in developing military rations that look freshly prepared yet can be kept at room temperature for up to three years. Besides meeting Army mobilization requirements, the technology reflects innovations in intermediate moisture food (IMF) technology, which carefully balances moisture, pH, and water binding to give foods soft, moist qualities without promoting microbiological growth. The team's work led to the development of several types of pocket sandwiches.

The team's transfer of IMF technology to industry resulted in the commercialization of the rations with Sara Lee Bakery. Working under two CRADAs, Sara Lee Bakery and SSCOM (NRDEC) are actively producing extended shelf-life bakery items that do not require refrigeration. A second CRADA with GoodMark Foods, Inc. focuses on developing and commercializing the meat-filled sandwich components. The team's success has also resulted in inquiries from other major industrial food organizations.

The technology simplifies shipping, distribution, and handling and increases solider acceptance, mobility, and consumption. The team's work also demonstrates how federal lab technology can strengthen the U.S. industrial base—providing synergistic benefits to all partners.

Chaos Control Applied to Cardiac Fibrillation and Epileptiform Behavior in the Brain

DOD-Navy-Carderock Division, Naval Surface Warfare Center

Drs. Mark Spano and Visarath In applied chaos control techniques to human biological systems—cardiac fibrillation and epileptiform behavior in the brain.

The doctors investigated controlling atrial fibrillation by altering and regulating local electrical activation of the high right atrium during atrial fibrillation—the most common arrhythmia requiring treatment. They also tried to regularize the electric spiking of the brain during epileptic seizures. With the Georgia Institute of Technology and Emory University, they began a course of experimental investigations that led to the successful application of chaos control.

Dr. Spano led his group in aggressively pursuing academic and commercial involvement in marketing applications of chaos control. This led to an innovative marketing agreement between UCLA and the Navy, which resulted in a license for the initial cardiac work to Medtronic, Inc. and Control Dynamics, Inc.

These techniques are now being applied to ventricular fibrillation—a severe heart dysfunction that is the leading killer of adults in the U.S. If this effort is as successful as the previous work, many lives could be saved.

Innovative Flat Panel Liquid Crystal Displays Offer Many Military and Commercial Uses

DOD-Navy - U.S. Naval Research Laboratory (NRL)

Dr. Ranganathan Shashidar pioneered the development of novel liquid crystal materials for advanced optical display devices and information processing and successfully transferred the technologies to the commercial and military sectors. His work encompasses two critical areas of liquid crystal displays (LCD)—the alignment of liquid crystals and the design of plastic substrates for LCDs.

In 1996, NRL entered a CRADA with Shipley Company and proposed Dr. Shashidar's novel approach to liquid crystal alignment as an alternative to conventional processing of LCDs. The CRADA was so successful that it was extended twice. Under the most recent extension, Shipley was granted a partially exclusive right and license to practice three of the inventions in the field of LCD manufacturing.

In 1997, NRL and Opticom ASA entered a CRADA to select, develop, and build a printing system to apply high resolution patterns of conducting and semiconducting materials onto flexible plastic substrates. This CRADA was recently amended to focus on commercialization.

Commercial applications of the technologies include flat panel displays of all kinds and are expected to significantly affect the $22 billion LCD industry. The technologies could replace the traditional polyimide process in existing manufacturing lines and may open new lines.

Environmentally Friendly, Inexpensive Solvents Commercialized

DOE-Argonne National Laboratory

Millions of pounds of toxic industrial solvents—many of which wind up polluting the environment—could soon be replaced by an environmentally friendly solvent made from agricultural feedstocks—thanks to a cost-cutting bioprocess developed by Argonne researcher Dr. James R. Frank.

The "green" solvent—ethyl lactate—has been used commercially since the 1980s; however, the price of $1.60 to $2.00 per pound did not allow for large-scale substitution of petroleum-based chlorinated and toxic solvents. By developing new separation/purification methods, Argonne solved fundamental technical issues and reduced the selling price of ethyl lactate to less than $1.00 per pound. Working with a small business industrial partner, NTEC Versol, Inc., Argonne transferred the technology, which has been licensed and is now being commercialized. This alliance also resulted in a start-up company, NTEC EDSep, Inc., that is working with industrial clients to solve industrial pollution prevention issues using electrodialysis.

Medical Device Improves Treatment of Cerebral Aneurysms and Hemorrhagic Stroke

DOE-Lawrence Livermore National Laboratory (LLNL)

Aneurysms form when the pressure of flowing blood causes a weakened artery wall to balloon and possibly rupture. Cerebral aneurysms are particularly dangerous because they can lead to hemorraghic stroke, severe brain damage, or death. More than 100,000 people suffer from hemorraghic strokes each year—with 50% proving fatal.

The transferred technology is an opto-mechanical coil release device that safely permits embolic coils to be positioned and released inside cerebral aneurysms. A fiber optic carries laser energy to a light-activated polymer that releases the metallic coil in less than a second. The device automatically detects the coil release and provides doctors with immediate feedback. Previous commercial systems took 5 to 15 minutes per coil and resulted in prolonged treatment times of several hours.

The cross-disciplinary LLNL team's efforts included developing the technology, demonstrating proof-of-concept, and assisting with the regulations process, user interface, and reliability and safety issues. The team's work was guided by a 1995 stroke summit held at the lab, which highlighted the need for an improved coil release mechanism. Micrus, Inc. licensed the technology and is now developing it for commercialization.

The device's potential to save lives, prevent serious disability, and improve lifetime productivity will reduce the taxpayer burden caused by strokes and help lower health-care costs.

Environmentally Friendly Solvent Cleaning System Developed for Clothing and Machined Parts

DOE-Pacific Northwest National Laboratory (PNNL)

A team effort of more than a decade culminated in the commercialization of a solvent cleaning method that provides the same cleaning power as organic solvents but without the hazards. The technology is a breakthrough for the environment and companies trying to meet increasingly stringent environmental regulations. It is also based on a nontoxic, readily available solvent—carbon dioxide (CO2).

The team took basic PNNL research on reverse micelles and worked with the founders of a new company—MICELL Technologies, Inc.—to license the technology. MICELL can now manufacture and sell highly effective, environ-mentally friendly, carbon dioxide-surfactant cleaning systems to dry cleaning and parts cleaning industries, among others.

In 1997, the U.S. Environmental Protection Agency honored the work with a Presidential Green Chemistry Challenge Award, which recognizes "fundamental breakthroughs in cleaner, cheaper, smarter chemistry." In 1998, the technology earned an R&D 100 Award from *Research and Development* magazine.

Innovative Fiber Optic Sensor Detects Presence of Radionuclides

DOE-Pacific Northwest National Laboratory (PNNL)

The team created and successfully commercialized a new radiation sensor that uses glass fibers to detect radionuclides. Early on, the team saw the technology's potential as a deterrent to nuclear weapons, for environ-mental cleanup, and as a valuable tool in nuclear medicine. Although faced with obstacles to commerc-ialization, the team obtained a license agreement with Oxford Instruments within one year of obtaining a patent.

The use of flexible glass fibers is a break-through because most neutron sensors use inflexible helium-filled tubes. In medicine, the sensor can be used with boron neutron capture therapy—a promising method to treat cancer patients. Another potential application is monitoring plutonium in spent fuel rods. The International Atomic Energy Agency is evaluating the technology for this application worldwide.

The technology is also of interest to researchers conducting materials science research and using neutron scattering to determine the structure of materials. The new sensor will provide more accurate information in less time than previous methods.

Indicator Device Detects Food Quality

HHS-Food and Drug Administration-National Center for Toxicological Research

The technology is a simple, inexpensive, quick, and effective device for determining the quality of food products. The device can be packaged with food stored in typical conditions and can be built into food packaging to verify freshness without opening the package or thawing the product. It works for fish, shrimp, milk, and red meat and, with modifications, can be used for any food product containing protein. Cox Recorders received a license to manufacture products based on the technology under the trade name Fresh Tag™.

The award recipients are now working with researchers at the University of Florida to validate specialized versions of the indicator that can assess—in one minute—the quality of frozen or fresh shrimp at dockside—a major challenge faced by the food industry.

Once it becomes industry standard, annual sales for the U.S. seafood industry alone should approximate $100 million.